Revolutionizing Plant Pathogen Conservation: The Past, Present, and Future of AI in Preserving Natural Ecosystems

Sue Han Lee[‡], Zhe Rui Jerad Liaw[‡], Yu Hao Abel Chai[‡], Shien Lin Jocelyn Ng[‡], Pierre Bonnet[§,|], Hervé H.G. Goëau[§,|], Alexis A.J. Joly[¶]

‡ Swinburne University of Technolgy, Sarawak, Malaysia
§ UMR AMAP, CIRAD, Montpellier, France
| AMAP, Univ Montpellier, CIRAD, CNRS, INRAE, IRD, Montpellier, France
¶ INRIA, Montpellier, France

Corresponding author: Sue Han Lee (adeline87lee@gmail.com), Pierre Bonnet (pierre.bonnet@cirad.fr)

Abstract

Traditionally, plant pathologists have emphasized controlling crop pathogens, neglecting the importance of conserving their diversity in natural ecosystems. Native plant pathogens thriving in natural environments significantly contribute to ecosystem structure, stability, nutrient cycling, and productivity. The coevolution of wild crop progenitors with native pathogens yields a diverse array of disease resistance factors, serving as a critical resource for farmers and breeders in developing disease-resistant cultivars. Moreover, native plant pathogens hold promise as valuable research tools, model systems for scientists, and potential sources of novel drugs, pesticides, bio-control agents, and biotechnological innovations (Ingram 1999, Ingram 2022)

Artificial Intelligence (AI) technology, specifically Deep Learning (DL), is revolutionizing agricultural sustainability by advancing plant disease identification (Ayoub Shaikh et al. 2022, Wongchai et al. 2022). DL extends beyond single-crop disease identification, encompassing multiple crops and diseases (Lee et al. 2020). Utilizing computer vision and Internet of Things (IoT), AI enhances the ability to recognize and categorize plant diseases across diverse agricultural landscapes (Sinha and Dhanalakshmi 2022). The data used is crowdsourced from images captured through cameras or smartphones.

However, to comprehensively monitor and understand plant diseases on a larger scale for diversity study, AI practitioners should integrate broader factors into their predictive modeling such as weather patterns, geographical variations, environmental conditions, and real-world challenges. Overcoming real-world challenges involves addressing previously unseen diseases, modeling disease distribution across extensive geographical areas, and managing domain adaptation, which arise from differences in data distributions between the source and target domains.

An innovative plant disease identification framework has been established, benchmarked on the largest plant disease dataset (Mohanty et al. 2016). This framework specifically focuses on addressing the crucial challenges in this field. The reliability of DL models was thoroughly analyzed and evaluated through machine vision interpretation, and cases lacking labeled data were explored (Chai et al. 2023). This presentation will not only highlight the significant advancements achieved but also outline future plans to new ecological studies of plant diseases identification as indispensable elements in the broader landscape of global environmental change research.

Keywords

plant disease identification, digital agriculture, deep learning, image analysis

Presenting author

Sue Han Lee

Presented at

SPNHC-TDWG 2024

Acknowledgements

We gratefully acknowledge the support of NEUON AI with the GPU workstation used for this research.

Funding program

This research is supported by FRGS MoHE Grant (Ref: FRGS/1/2021/ICT02/SWIN/03/2) from the Ministry of Higher Education Malaysia; and the Swinburne Sarawak Research Supervision Grants (SSRSG) (Ref: SUTS/SoR/RMC/SSRGS/2023). This work was also partially funded by the French National Research Agency (ANR) through the grant Pl@ntAgroEco "ANR-22-PEAE-0009".

Conflicts of interest

The authors have declared that no competing interests exist.

References

- Ayoub Shaikh T, Rasool T, Rasheed Lone F (2022) Towards leveraging the role of machine learning and artificial intelligence in precision agriculture and smart farming. Computers and Electronics in Agriculture 198 https://doi.org/10.1016/j.compag.2022.107119
- Chai AYH, Lee SH, Tay FS, Then YL, Goëau H, Bonnet P, Joly A (2023) Pairwise Feature Learning for Unseen Plant Disease Recognition. 2023 IEEE International Conference on Image Processing (ICIP) https://doi.org/10.1109/icip49359.2023.10222401
- Ingram DS (1999) Biodiversity, plant pathogens and conservation. Plant Pathology 48 (4): 433-442. https://doi.org/10.1046/j.1365-3059.1999.00361.x
- Ingram DS (2022) A case for conserving plant pathogens. Plant Pathology 71 (1): 98-110. https://doi.org/10.1111/ppa.13448
- Lee SH, Goëau H, Bonnet P, Joly A (2020) New perspectives on plant disease characterization based on deep learning. Computers and Electronics in Agriculture 170 https://doi.org/10.1016/j.compag.2020.105220
- Mohanty S, Hughes D, Salathé M (2016) Using Deep Learning for Image-Based Plant Disease Detection. Frontiers in Plant Science 7 https://doi.org/10.3389/fpls.2016.01419
- Sinha BB, Dhanalakshmi R (2022) Recent advancements and challenges of Internet of Things in smart agriculture: A survey. Future Generation Computer Systems 126: 169-184. https://doi.org/10.1016/j.future.2021.08.006
- Wongchai A, Jenjeti Dr, Priyadarsini AI, Deb N, Bhardwaj A, Tomar P (2022) Farm monitoring and disease prediction by classification based on deep learning architectures in sustainable agriculture. Ecological Modelling 474 https://doi.org/10.1016/j.ecolmodel.2022.110167